# NAMURIAN PLANT SPORES FROM THE SOUTHERN PENNINES, ENGLAND

*by* R. NEVES

ABSTRACT. Selected fossil spores from coals and carbonaceous shales of Namurian age from the Southern Pennines area of England are described, and their stratigraphic ranges given with reference to the standard sequence of goniatite stages. The types of sediment in which the spores are found are recorded, and the apparent association of certain spore types with particular sediments is discussed. Two new series of fossil spores are proposed—Pseudocingulati and Membranati; two new genera—*Secarisporites* and *Hymenospora*—and twenty-seven new species are described and illustrated. Disaccate pollen grains of the *Pityosporites-Vesicaspora* type are recorded for the first time from strata of Namurian age.

THE value of fossil plant spores for purposes of coal-seam correlation has been adequately demonstrated by Kosanke (1950), Balme and Butterworth (1952), and Butterworth and Millott (1954 and 1955). These authors were concerned with typical coal-measures sequences in which the coal seams form a prominent lithological constituent. In other sedimentary successions, however, coal seams are often absent or, if present, are of spasmodic occurrence and limited areal extent. Such is the case in the Namurian succession of the Southern Pennines area of England, where carbonaceous shales provide the most readily available source of fossil spores. The spore assemblages obtained from the thin coals are used to supplement the data obtained from studies of the shales.

Hoffmeister, Staplin, and Malloy (1955) and Neves (1958) have already indicated that the types of spores present and their relative abundance differ considerably in coal seams and closely allied carbonaceous shales. Such an occurrence is to be expected, in that the spores obtained from coal will mainly represent a parent vegetation which, although rich in constituent members, is of a somewhat restricted and specialized nature; the vegetation consisting of plants which are adapted to the swamp environment. It is probable, therefore, that certain spore types produced by a vegetation which existed outside the coal swamps will not be represented in the coal-seam assemblages. However, should some of these spores have been carried into the swamp region by wind or water agencies, their presence will be masked to the observer, by the profusion of spore types dispersed more or less *in situ* from the local swamp vegetation. The allochthonous nature of the shales, on the other hand, implies that the contained fossil spores will be derived from a variety of parent plant associations occupying various ecological stations. The assemblages preserved in shales will be representative of the vegetation which was growing in and around the basin of sedimentation. Consequently the complete microflora and the absolute time ranges of the component forms can only be obtained by an examination of all those sedimentary types which make up the geological succession of the region. In this way the succession of coal swamp vegetations, as represented by the coal seams, will be determined and the characteristics of other contemporaneous vegetation established. The sum total of this combined evidence enables a closer appreciation of the flora to be achieved, and this appears to be an essential criterion in the utilization of microfloral evidence to the problems of stratal subdivision.

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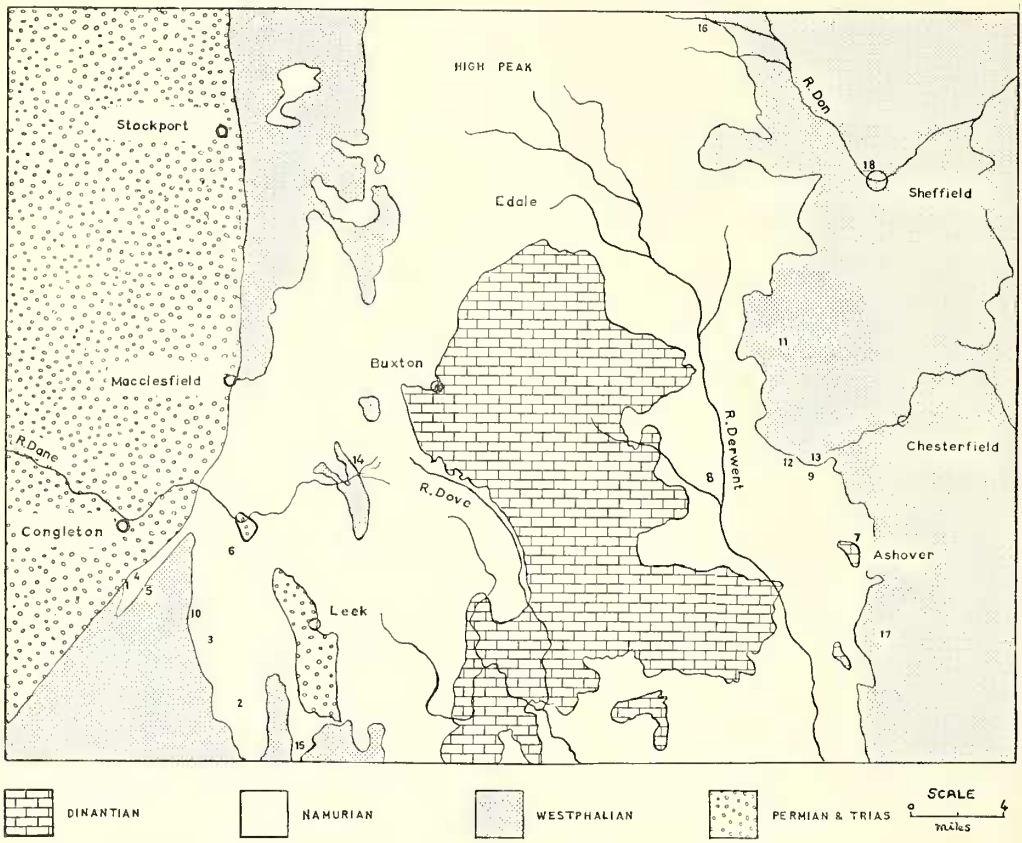
In the present paper, certain new spores are described from coals and shales of Namurian age from the Southern Pennines area of England. The stratigraphical occurrences of these spores in this region, together with several already described species, have been recorded and are shown in Table 1. These spores have been selected on account of their value as stratigraphic indicators and represent a small part of the




TEXT-FIG. 1. Index map of localities and outcrop distribution in the Southern Pennines Basin.

total Namurian microflora. The sequence of goniatite stages, which is used as the basis for Table 1, is that proposed by Bisat (1928, p. 117) and subsequently redefined by Hudson and Cotton (1943, p. 152).

The majority of the samples used during the investigation were collected by the author from outcrop and mine exposures which are described in literature and are listed below. Other samples were kindly provided by Dr. R. M. C. Eagar from the Wigan district in the west of the region. A sketch map of the region (text-fig. 1) indicates sample localities and the outcrop of the Namurian measures.

*Stratigraphy and palaeogeography.* The Southern Pennines area of the Central Province of England, comprising parts of Yorkshire, Lancashire, Derbyshire, Cheshire, and Staffordshire, was a region of general subsidence throughout Upper Carboniferous

times. The basin of sedimentation was bounded to the south by the land mass of St. George's Land and to the north by the Lake District and Southern Uplands massifs. Within the basin, the areas of maximum subsidence and sedimentation were not constant so that locally non-sequences and even unconformities are present at the base of the Namurian successions.

The stratigraphical succession of the region, based mainly on the goniatite faunas contained in the marine shales, has been thoroughly established through the work of Bisat (1928), Bisat and Hudson (1943), Hudson and Cotton (1943, 1945), Jackson (1927), Hester (1932), Cope (1945), and Trotter (1951). In general, the lower stages of the Namurian, when present, consist of marine, argillaceous deposits interleaved with thin, sandy horizons or crowstones. The younger Namurian measures are characterized by an increased arenaceous component which takes the form of thick, lenticular beds of sandstone and gritstone, such as the Kinderscout Grit series. Observations on current bedding carried out by Gilligan (1920) in the northern areas and the author in the southern parts of the basin indicate that the arenaceous material was derived both from the north and south respectively. Sometimes associated with the sandy horizons are thin coals and bluish grey, non-marine shales, which give rise to a primitive form of rhythmic sedimentation of the coal-measure type in the higher Namurian stages.

*List of sample localities and horizons examined.* The locality numbers correspond to those used in text-fig. 1 and also occurring in the section dealing with the Systematic Palaeontology.

1. Exposure in lane leading to Limekiln Farm, near Congleton, Staffordshire (G.R. SJ. 861591). Astbury Coal, Pendleian stage.
2. Exposure near Moor Hall Farm, Bagnall, Staffordshire (G.R. SJ. 945509). Horizon: marine shale with *Eumorphoceras bisulcatum* Girty.
3. Stream exposure, Hollywood Dingle, near Endon, Staffordshire (G.R. SJ. 928554). Horizon: marine shale with *Anthracoceras paucilobum.*
4. Ganister Quarry, Congleton Edge, Staffordshire (G.R. SJ. 869591).
   Horizons: Marine shale with *Hudsonoceras proteum.*
   Grey Non-marine shales.
   Thin Coal Seam.
5. Tip from old workings of the Congleton Edge Coal, near Biddulph, Staffordshire (G.R. SJ. 870590). Horizon: coal seam above Congleton Edge Grit, Marsdenian stage.
6. Stream exposure south of Rushton Hall, north Staffordshire (G.R. SJ. 928614). Horizon: Marine shale with *Reticuloceras inconstans* s.l.
7. Exposure in Marsh Brook, Ashover, Derbyshire (G.R. SK. 344634). Horizon: marine shale with *Reticuloceras inconstans* s.l.
8. Stream exposure in Lindup Wood, near Rowsley, Derbyshire (G.R. SK. 255675). Horizon: marine shales with *Reticuloceras bilingue.*
9. Sandstone quarry, Stone Edge, Derbyshire (G.R. SK. 344674). Horizon: Baslow Coal, Marsdenian stage.
10. Stream exposure, Crowborough Wood, near Biddulph, Staffordshire (G.R. SJ. 902556). Horizon: marine shales with *Gastrioceras cancellatum.*
11. Smeekley Bore Hole, Cordwell Valley, Derbyshire (G.R. SK. 296767).
    Horizons: Marine shale with *Gastrioceras listeri.*
    Marine shale with *Gastrioceras subcrenatum.*
    Non-marine shale with *Carbonicola exporrecta.*
    Marine shale with *Gastrioceras cancellatum.*
12. Exposures in stream banks, Hipper Sick, Derbyshire (G.R. SK. 312683).
    Horizons: Marine shale with *Gastrioceras subcrenatum.*
    Non-marine shale with *Carbonicola exporrecta.*

Marine shale with *Gastrioceras cumbriense*.
Marine shale with *Gastrioceras cancellatum*.

13. Ganister Drift Mine, Holymoorside, Derbyshire (G.R. SK. 327680).
Horizons: Marine shale with *Gastrioceras subcrenatum*.
Pot Clay Coal and non-marine roof shales.
14. Stream exposure, near The Wash, Quarnford, Staffordshire (G.R. SJ. 014662). Horizons: as locality 13.
15. Stream exposure, near Consall village, Staffordshire. (G.R. SJ. 975483). Horizon: Six Inch Mine Coal. Yeadonian stage.
16. Exposure in the bank of the Little Don river, near Langsett, Yorkshire (G.R. SE. 222005). Horizons: as localities 13 and 14.
17. Ganister Quarry, Wessington, Derbyshire (G.R. SK. 349566). Horizons: marine shale with *Gastrioceras listeri*, and Alton Coal.
18. Ganister Drift Mine, Neepsend, Sheffield, Yorkshire. Horizons: as locality 17.

*Previous palynological literature.* Literature dealing with Namurian plant spores is available from several continents. Luber and Waltz (1938) described Lower Carboniferous assemblages from the Moscow and Karaganda Basins of the U.S.S.R.; Ischenko (1952, 1956, and 1958) published his work on the fossil plant spores from coals of the Donetz and Dneiper Basins; Horst (1955) dealt with the Namurian spores of Upper Silesia and in 1957 Dybova and Jachowicz gave a further account of Upper Carboniferous spores from this region; Artuz (1957, 1959) described the spore assemblages of three coal seams of Namurian and Lower Westphalian A age, from the Zonguldak Coalfield of Turkey. Hoffmeister, Staplin, and Malloy (1955) gave the results of an investigation into the plant spore assemblages contained in coals and shales of Upper Mississippian age from Illinois and Kentucky, U.S.A. In Britain, Millott (1939) considered briefly the fossil spores found in certain coal seams of Namurian age from north Staffordshire; Knox (1942) and Butterworth and Williams (1958) investigated the small spore content of coal seams of Namurian A age in the Limestone Coal Group and the Upper Limestone Group of Scotland. The present author (Neves, 1958) gave a preliminary account of an investigation into the plant spore content of coals and associated carbonaceous shales from the Central Province of England. Most authors, however, have been concerned with the small spore assemblages present in coal seams, with little attention having been directed to the spore content of shales. Furthermore, the stratigraphical occurrences of the various spore types are rarely referred directly to the established sequence of goniatite zones.

*Maceration techniques.* The various methods which have been employed for the isolation of organic remains from coals and shales have been fully described elsewhere by several authors. The technique used throughout the present work relies on Schulze solution to oxidize the humic matter which is in close association with the plant tissues. The oxidized products were then removed in a dilute solution of potassium hydroxide. The mineral matter of the shales is eliminated by digestion in hot hydrofluoric acid following an initial treatment with bromine to break the shale down. The details of the technique are more fully described in Neves (1958).

## SYSTEMATIC PALAEONTOLOGY

The system proposed by Potonié and Kremp (1954) for the description and classification of the fossil dispersed spores is used in this account. Slight modifications are introduced

where it is considered to be of practical advantage in light of additional information. Two new Series, Pseudocingulati and Membranati, are erected to accommodate newly described spore types. Two new genera, *Secarisporites* and *Hymenospora*, are described and illustrated together with new species of the following genera: *Leiotriletes*, *Punctatisporites*, *Acanthotriletes*, *Ibrahimispores*, *Neoraistrickia*, *Mooreisporites*, *Camptotriletes*, *Dictyotriletes*, *Convolutispora*, *Secarisporites*, *Ahrensisporites*, *Triquitrites*, *Densosporites*, *Knoxisporites*, *Stenozonotriletes*, *Cirratriradites*, *Proprisporites*, and *Tholisporites*. As a result of observations made during the course of the present investigation, the genus *Knoxisporites* Potonié and Kremp 1954 is here transferred to the Series Cingulati Details of occurrence are given in Table 1 or in the text.

All slides referred to in the text are lodged in the Micropalaeontology Laboratory, Department of Geology, University of Sheffield.

Division SPORITES H. Potonié 1893
Group TRILETES Reinsch 1881
Subgroup AZONOTRILETES Luber 1935
Series LAEVIGATI (Bennie and Kidston) Potonié 1956
Genus LEIOTRILETES (Naumova) Potonié and Kremp 1954

*Type species. L. sphaerotriangulus* (Loose) Potonié and Kremp 1954

*Leiotriletes densus* sp. nov.

Plate 30, figs. 1, 2

*Holotype*. Plate 30, fig. 1.

*Type locality*. Non-marine roof shales of the Pot Clay Coal, Langsett, Yorkshire (Loc. 16). Yeadonian stage.

*Diagnosis*. Size range 85–110 $\mu$ (fifteen specimens measured), holotype 96 $\mu$; equatorial outline triangular; trilete rays three-quarters radius of the spore; exine dense and thick.

*Description*. Colour dark brown. Equatorial outline triangular, sides straight to slightly convex, apices broadly rounded. Trilete rays prominent, lips thin, sutures usually closed. Exine thick, laevigate to faintly infrapunctate.

*Comparison*. The compact triangular shape, longer trilete rays, and the absence of a darkened contact region distinguish these spores from those of the species *L. grandis* (Kosanke) Bhardwaj 1957.

*Occurrence*. Upper Namurian C and Lower Westphalian A, rare.

Genus PUNCTATISPORITES (Ibrahim) Potonié and Kremp 1954

*Type species. P. punctatus* Ibrahim 1933

*Punctatisporites pseudopunctatus* sp. nov.

Plate 30, fig. 3

*Holotype*. Plate 30, fig. 3.

*Type locality*. Non-marine shale with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 11). Yeadonian stage.

*Diagnosis*. Size range 90–120 $\mu$ (nineteen specimens measured), holotype 116 $\mu$; equatorial outline subcircular; trilete rays short, approximately half spore radius; exine strongly and densely infrapunctate.

*Description*. Colour light brown to yellow. Tecta of the tetrad mark tapering, lips often associated with small folds. At the margin of the compressed spores a narrow 'rim', 2–3 $\mu$ wide, is present. The inner line of the 'rim', corresponding to the intexine membrane, clearly shows the infra-punctate nature of the exine. Outline smooth. Small secondary folds of the exine occur infrequently.

*Comparison*. The spores of this species are slightly larger than those of *P. aerarius* Butterworth and Williams 1958, and the structure of the exine is much stronger. *P. grandis* and *P. pseudoelevatus* Hoffmeister, Staplin, and Malloy 1955 differ in possessing a positive surface ornamentation.

*Occurrence*. Namurian A and C; sometimes common, particularly in marine shales.

### *Punctatisporites giganteus* sp. nov.

Plate 30, fig. 4

*Holotype*. Plate 30, fig. 4.

*Type locality*. Marine shale with *Eumorphoceras bisulcatum* Girty, Bagnall, Staffordshire (Loc. 2). Arnsbergian stage.

*Diagnosis*. Size range 150–170 $\mu$ (ten specimens measured), holotype 158 $\mu$; equatorial outline subcircular to subtriangular; trilete rays two-thirds to three-quarters radius of the spore; exine laevigate to strongly infrapunctate.

*Description*. Colour yellow-brown; exine 2–3 $\mu$ thick, margin smooth, occasional secondary folds. Trilete rays distinct; lips thin, subparallel to tapering.

*Comparison*. *P. obesus* (Loose) Potonié and Kremp is smaller.

*Occurrence*. Namurian A, rare.

### *Punctatisporites* (*Sinuspores*) *sinuatus* (*Artuz*) comb. nov.

1958 *Punctatisporites densoarcuatus* Neves; p. 6, pl. ii, fig. 7.
1958 *Punctatisporites coronatus* Butterworth and Williams; p. 360, pl. i, fig. 12.

*Remarks*. *Sinuspores sinuatus* was described by Artuz (1957, p. 254) as possessing a variably thickened exine and a 'Gurtelzone'. Neves (1958, p. 6) and Butterworth and Williams (1958, p. 360) described this structure as simple exinous folding. The material examined by the current author clearly shows all stages in the development of the pronounced curving fold as seen in the holotype (Artuz 1957, pl. 7, fig. 48), from simple,

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EXPLANATION OF PLATE 30

All magnifications $\times 500$.

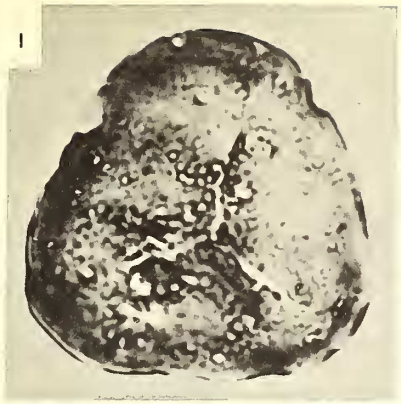
Figs. 1–2. *Leiotriletes densus* sp. nov. Slide ref. s.Z. 1, holotype, 96 $\mu$. 2, 96 $\mu$.

Fig. 3. *Punctatisporites pseudopunctatus* sp. nov., holotype, 116 $\mu$. Slide ref. s.H.

Fig. 4. *Punctatisporites giganteus* sp. nov., holotype, 158 $\mu$. Slide ref. s.B.

Fig. 5. *Acanthotriletes slendidus* sp. nov., holotype, distal surface, 105 $\mu$. Slide ref. 5.261818.

Figs. 6–7. *Acanthotriletes ? pilus* sp. nov. 6, holotype, 69 $\mu$. 7, 84 $\mu$. Slide ref. s.E.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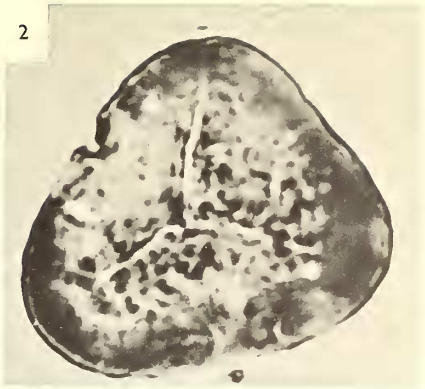
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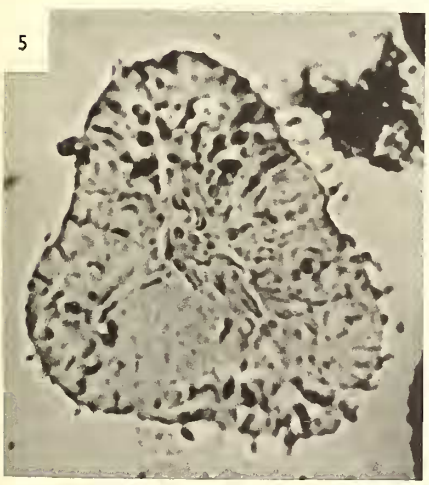
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small amplitude folds of the exine. Since these structures are clearly secondary effects it is proposed to transfer the species *S. sinuatus* Artuz to the genus *Punctatisporites*.

*Occurrence*. Artuz (1957)—Westphalian A. Butterworth and Williams (1958)—Namurian A of Scotland.

Series APICULATI (Bennie and Kidston) Potonié 1956
Genus APICULATISPORIS Potonié and Kremp 1956

*Type species*. *A. aculeatus* (Ibrahim) Potonié and Kremp 1954

*Apiculatisporis maculosus* (Knox) Potonié and Kremp 1955

*Occurrence*. Lower Namurian A, rare. Butterworth and Williams (1958) recorded this species from the Namurian A measures of Scotland.

Genus ACANTHOTRILETES (Naumova) Potonié and Kremp 1954

*Type species*. *A. ciliatus* (Knox) Potonié and Kremp 1954

*Acanthotriletes splendidus* sp. nov.

Plate 30, fig. 5

*Holotype*. Plate 30, fig. 5.

*Type locality*. Marine shale with *Anthracoceras paucilobum*, Hollywood Dingle, Staffordshire (Loc. 3). Arnsbergian stage.

*Diagnosis*. Size range 90–110 $\mu$ (ten specimens measured), holotype 105 $\mu$; equatorial outline triangular; trilete rays two-thirds spore radius; exine ornamented with slender, broad-based spines; thirty to fifty spines overtop the equatorial margin.

*Description*. Colour light brown. Equatorial outline triangular, sides concave, apices rounded. Trilete rays with narrow lips, sutures sometimes open. The spines which ornament the exine are 2–10 $\mu$ high, and 2–4 $\mu$ wide at the base. The spines are not densely spaced and there is room between them for elements of equal size. Exine between spines laevigate.

*Comparison*. These spores are characterized by their large size and the ornament of slender spines. *Acanthotriletes horridus* Hacquebard 1957 is larger and possesses stronger more densely spaced spines.

*Occurrence*. Namurian A, rare.

*Acanthotriletes? pilus* sp. nov.

Plate 30, figs. 6, 7

*Holotype*. Plate 30, fig. 7.

*Type locality*. Marine shale with *Gastrioceras cancellatum*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

*Diagnosis*. Size range 50–90 $\mu$ (twenty specimens measured), holotype 84 $\mu$; equatorial outline rounded triangular; trilete rays two-thirds to three-quarters radius of the spore; exine densely covered by short, slender, 'mushroom'-topped pila.

*Description.* Colour light brown to yellow. Original shape ± globular, and the spores are often compressed obliquely with no preferred orientation. Trilete rays straight, tecta slightly tapering, lips thin. Exine 2 $\mu$ thick, decorated by closely spaced, discrete pila the tips of which are expanded to a mushroom form; height 2–3 $\mu$, width at base 0·5–1 $\mu$.

*Comparison. Acanthotriletes* (*Azonotriletes*) *multisetosus* (Luber and Waltz) Potonié and Kremp 1955 is superficially similar to *A*? *pilus*. However, the spores of the former species are rounded to oval in outline and the ornament consists of essentially parallel-sided spines.

*Occurrence.* Namurian C; this species has been recorded only from the type horizon.

*Acanthotriletes baculatus* sp. nov.

Plate 31, fig. 1

*Holotype.* Plate 31, fig. 1.

*Type locality.* Marine shale with *Hudsonoceras proteum*, Congleton Edge ganister quarry, Staffordshire (Loc. 4). Sabdenian stage.

*Diagnosis.* Size range 34–45 $\mu$ (fifteen specimens measured), holotype 34 $\mu$; equatorial outline triangular; trilete rays two-thirds radius of the spores; exine beset with upstanding blunted spines; fifteen to twenty elements occur at the equatorial margin.

*Description.* Colour pale yellowish-brown. Equatorial outline triangular, sides concave, apices rounded. Rays of the trilete mark simple, often obscured by the ornamentation elements which consist of relatively long, in part parallel sided, and terminally truncate spines; height 4–10 $\mu$, width 1–2·5 $\mu$. The spines are not densely set and between them the exine is laevigate.

*Comparison. Acanthotriletes falcatus* has stouter, cone-like spines which are closely spaced; in *A. castanea* the spines are uniformly tapering and more densely set.

*Occurrence.* Namurian A, infrequent.

Genus IBRAHIMISPORES Artuz 1957

*Type species. I. microhorridus* Artuz 1957

*Ibrahimispores brevispinosus* sp. nov.

Plate 31, fig. 2

*Holotype.* Plate 31, fig. 2.

EXPLANATION OF PLATE 31

All magnifications × 500.

Fig. 1. *Acanthotriletes baculatus* sp. nov., holotype, 34 $\mu$, distal view. Slide ref. 1.302744.

Fig. 2. *Ibrahimispores brevispinosus* sp. nov., holotype, 80 $\mu$, distal view. Slide ref. s.Y.

Fig. 3. *Ibrahimispores magnificus* sp. nov., holotype, 81 $\mu$, distal view. Slide ref. s.Ao.

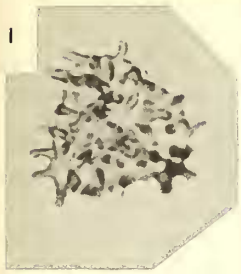
Fig. 4. *Neoraistrickia inconstans* sp. nov., holotype, 71 $\mu$, distal view. Slide ref. 1.285759.

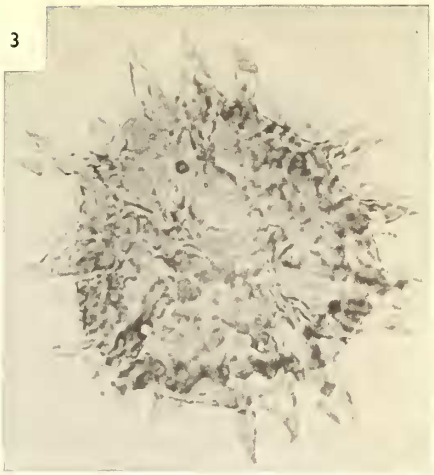
Fig. 5. *Mooreisporites trigallerus* sp. nov., holotype, 77 $\mu$, distal view. Slide ref. s.T.

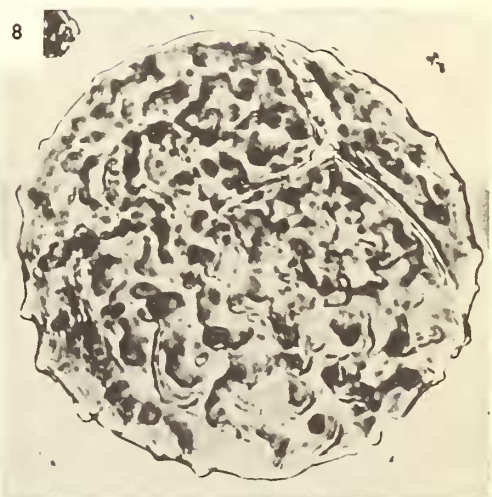
Fig. 6. *Mooreisporites fustis* Neves, distal view, 75 $\mu$.

Fig. 7. *Mooreisporites bellus* sp. nov., holotype, 105 $\mu$, distal view. Slide ref. s.E.

Fig. 8. *Camptotriletes superbus* sp. nov., holotype, 119 $\mu$, proximo-lateral view focus low on ornament. Slide ref. 3.240769.







NEVES, Namurian microspores

*Type locality*. Non-marine shales with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 11). Yeadonian stage.

*Diagnosis*. Size range 70–100 $\mu$ (fifteen specimens measured), holotype 80 $\mu$; equatorial outline rounded-triangular; exine ornamented with stout, hollow pointed spines which are thickened at the tips.

*Description*. Colour yellow-brown to brown. Equatorial outline rounded-triangular to subcircular. The rays of the trilete mark are usually associated with dark, flexuous folds of the exine; approximately three-quarters radius of the spores. The ornamentation elements are short, hollow spines, $\pm$ uniformly tapering to the sharply pointed, solid tip. Spines 6–10 $\mu$ high, 3–5 $\mu$ wide at the base and are densely spaced; forty to fifty elements occur at the equatorial outline.

*Comparison*. *I. microhorridus* Artuz is more circular in outline and the spines appear to be solid and without thickened tips.

*Ibrahimispores magnificus* sp. nov.

Plate 31, fig. 3

*Holotype*. Plate 31, fig. 3.

*Type locality*. Non-marine shale with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 11). Yeadonian stage.

*Diagnosis*. Size range 75–90 $\mu$ (ten specimens measured), holotype 81 $\mu$; equatorial outline rounded-triangular, sides convex, apices broadly rounded; trilete mark often obscured by dark flexuous folds of the exine. Exine beset with long, hollow pointed spines; fifteen to twenty elements occur at the equatorial margin.

*Description*. Colour light brown. The large spines which decorate the exine are not densely set and elements of equal size could be placed between them. Spines 15–20 $\mu$ high, 3–8 $\mu$ wide at the base. The tips of the spines are solid and appear as darker, conical terminations; bifurcation of the spines is infrequently seen. Exine infra-punctate between the spines.

*Comparison*. *I. magnificus* is probably closely related to *I. brevispinosus*. However, on account of the recognizable difference in size and disposition of the ornamentation elements, it proposed as a new species.

*Occurrence*. Namurian C, rare.

Genus NEORAISTRICKIA Potonié 1956

*Type species*. *N. truncatus* (Cookson) Potonié

*Neoraistrickia inconstans* sp. nov.

Plate 31, fig. 4

*Holotype*. Plate 31, fig. 4.

*Type locality*. Marine shale with *Hudsonoceras proteum*, Congleton Edge ganister quarry, Staffordshire (Loc. 4). Sabdenian stage.

*Diagnosis*. Size range 55–75 $\mu$ (twenty specimens measured), holotype 71 $\mu$; equatorial

outline triangular, sides concave to straight, apices rounded. Trilete rays two-thirds spore radius. Distal surface and proximal surface decorated with short baculae.

*Description.* Colour light brown. Trilete rays distinct, tecta straight, lips thin. Exine laevigate between ornamentation elements. The baculae which are present on the distal surface of the spores are 3–8 $\mu$ high, 2–4 $\mu$ wide, parallel-sided elements; interspersed between these are small, blunt conical projections. The ornamentation encroaches on to the proximal surface of the spores, particularly in the region of the spore body apices. Whilst the latter radial regions may be densely ornamented, the inter-radial margin is often devoid of projections.

*Comparison.* The triangular equatorial outline and the baculose ornamentation are typical of the genus *Neoraistrickia.*

*Occurrence.* Namurian A, fairly common at specific horizons.

## Genus MOOREISPORITES Neves 1958

*Type species. M. fustis* Neves 1958

### *Mooreisporites trigallerus* sp. nov.

Plate 31, fig. 5

*Holotype.* Plate 31, fig. 5.

*Type locality.* Marine shale with *Hudsonoceras proteum*, Congleton Edge ganister quarry, Staffordshire (Loc. 4). Sabdenian stage.

*Diagnosis.* Size range 55–80 $\mu$ (thirty specimens measured), holotype 77 $\mu$; equatorial outline triangular; trilete rays short, half radius of the spore; apices of spore body ornamented with short, fused baculae.

*Description.* Colour light brown, apical ornament darker. Equatorial outline triangular, sides straight, apices expanded due to the projecting baculae. Trilete rays short, lips thin, suture narrow. Exine ornamented overall with small, scattered coni. At the apices of the spore body short baculae are developed, size 8–10 $\mu$ high; these elements are often fused laterally in the lower part.

*Comparison. Triquitrites tricuspis* is similar but possesses a narrow equatorial cingulum (Horst 1955, p. 175); *Tripartites lucidus* Artuz 1957 is slightly larger and the rays of the trilete mark reach the margin of the spore body. *Mooreisporites fustis* is characterized by heavy branching baculae both in the apical regions and also on the distal surface of the spores.

*Remarks. Mooreisporites trigallerus* sp. nov. should not be placed in the genus *Tripartites* (Schemel) Potonié and Kremp 1954 since none of the specimens observed possesses the inter-radial, equatorial flange which is present in *Tripartites vetustus*, the type species of the genus.

*Occurrence.* Namurian A, common at certain horizons.

### *Mooreisporites fustis* Neves 1958

Plate 31, fig. 6

*Occurrence.* Spores of this species first appear in the Upper Namurian A assemblages and are to be found in both shale and coal preparations.

*Mooreisporites bellus* sp. nov.

Plate 31, fig. 7

*Holotype*. Plate 31, fig. 7.

*Type locality*. Baslow Coal, Stone Edge Quarry, Derbyshire (Loc. 9). Marsdenian stage.

*Diagnosis*. Size range 95–115 $\mu$ (fifteen specimens measured), holotype 105 $\mu$; exine decorated with small scattered coni; apical regions with large, irregular patches of thickening and terminal baculae.

*Description*. Colour light brown, apical thickening dark brown. Trilete rays half radius of the spore body, suture and lips narrow. The large, bifurcating baculae, which project beyond the apical margins of the spores, arise from extensive, irregular patches of distal thickening. The latter often extend polewards on the distal surface. The baculae are 4–8 $\mu$ wide, of variable height and with partate terminations.

*Comparison*. *M. bellus* is characterized by spores of large size, possessing in the radial positions irregular patches of exinous thickening from which arise the squat baculae seen at the spore margin.

*Genus* VERRUCOSISPORITES (Ibrahim) Potonié and Kremp

*Type species*. *V. verrucosus* Ibrahim 1933

*Remarks*. The spores of this genus are very rare in the Namurian assemblages of the Central Province of England.

*Verrucosisporites morulatus* Knox 1950

*Remarks*. For description see Knox (1950) and Butterworth and Williams (1958 p. 62).

*Occurrence*. Lower Namurian A, rare. Butterworth and Williams (1958) found this species was confined to the Limestone Coal Group of Scotland.

Series MURORNATI Potonié and Kremp 1954
Genus CAMPTOTRILETES (Naumova) Potonié and Kremp 1954

*Type species*. *C. corrugatus* (Ibrahim) Potonie and Kremp 1954

*Camptotriletes superbus* sp. nov.

Plate 31, fig. 8

*Holotype*. Plate 31, fig. 8.

*Type locality*. Pot Clay Coal, Holymoorside, Derbyshire (Loc. 13). Yeadonian stage.

*Diagnosis*. Size 75–125 $\mu$ (thirty specimens measured), holotype 119 $\mu$; equatorial outline subcircular; trilete rays long, three-quarters radius of the spore, tecta sharp and tapering. Exine ornamented with irregular, disjointed, subconical ridges.

*Description*. Colour golden to reddish-brown. Spore margin overtopped by twenty to twenty-five rounded, conical processes. The discontinuous ridges which ornament the surface of the spores are 3–5 $\mu$ high and up to 25 $\mu$ long; and appear as a verrucose to

conate ornament in which the elements are connected laterally by irregular ridges. The ridges are separated by irregular regions of thinner, laevigate exine.

*Comparison.* The spores of this species are characterized by their large size and the variable nature of the rudimentary cristae.

*Occurrence.* Upper Namurian B–Westphalian A, common in certain coal-seam assemblages.

*Camptotriletes verrucosus* Butterworth and Williams 1958

*Occurrence.* Lower Namurian A, rare. The species was originally described from the Limestone Coal Group of Scotland.

## Genus DICTYOTRILETES (Naumova) Potonié and Kremp 1954

*Type species. D. bireticulatus* (Ibrahim) Potonié and Kremp 1954

### *Dictyotriletes tuberosus* sp. nov.

Plate 32, fig. 1

*Holotype.* Plate 32 fig. 1.

*Type locality.* Marine shale with *Hudsonoceras proteum*, Congleton Edge ganister quarry, Staffordshire (Loc. 4). Sabdenian stage.

*Diagnosis.* Size range 90–120 $\mu$ (ten specimens measured), holotype 120 $\mu$, equatorial outline subcircular to oval; exine decorated with very strong muri which appear as rounded elevations at the spore margin; the muri enclose seven to twelve large lacunae.

*Description.* Colour light brown, muri dark brown. Trilete rays three-quarters spore radius, lips often slightly thickened. The muri of the reticulum are heavy, solid walls, 5–10 $\mu$ wide at the base, 5–7 $\mu$ high, and rounded conical in profile. The lacunae enclosed by the muri are large and of variable shape.

*Comparison. Dictyotriletes* (*Azonotriletes*) *subalveolaris* (Luber) Potonié and Kremp 1955 resembles *D. tuberosus* in the nature of the muri, however in the former species, there are many more lacunae present in the reticulum. The muri in *D. tuberosus* show no tendency for the membranous zone at the spore outline, a feature which characterizes the genus *Reticulatisporites*.

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EXPLANATION OF PLATE 32

All magnifications $\times 500$.

Fig. 1. *Dictyotriletes tuberosus* sp. nov., holotype, 120 $\mu$, distal surface, focus low. Slide ref. s.A.

Fig. 2. *Convolutispora* sp. A., distal view, 122 $\mu$.

Fig. 3. *Convolutispora obliqua* sp. nov., holotype, 122 $\mu$, focus low on ornament. Slide ref. 1.295827.

Figs. 4–5. *Convolutispora laminosa* sp. nov. 4, Holotype, 72 $\mu$, distal view. Slide ref. 7.221665. 5, Proximo-lateral view, 69 $\mu$.

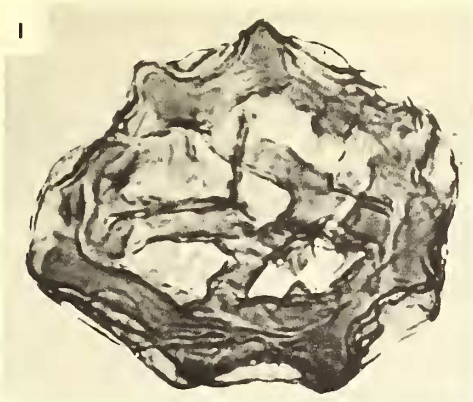
Figs. 6–7. *Secarisporites lobatus* sp. nov. 6, Holotype, 81 $\mu$, proximal view and low focus. Slide ref. 4. 175850. 7, Distal view, 80 $\mu$.

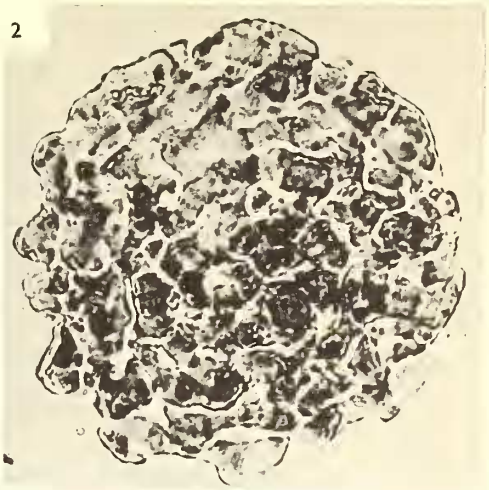
Figs. 8–9. *S. remotus* sp. nov. 8, Distal view, 48 $\mu$. 9, Holotype, proximal view, 46 $\mu$. Slide ref. 8.343708.

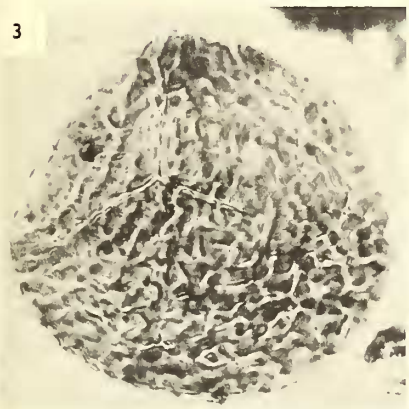
Fig. 10. *Ahrensisporites beeleyensis* sp. nov., holotype, 56 $\mu$, distal view, low focus. Slide ref. s.Z.

Fig. 11. *Ahrensisporites guerickei* var. *ornatus* var. nov., holotype, 66 $\mu$, distal surface. Slide ref. 4.296768.

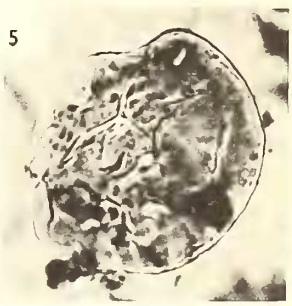
Fig. 12. *Triquitrites nodosus* sp. nov., holotype, 88 $\mu$. Slide ref. s.Av.

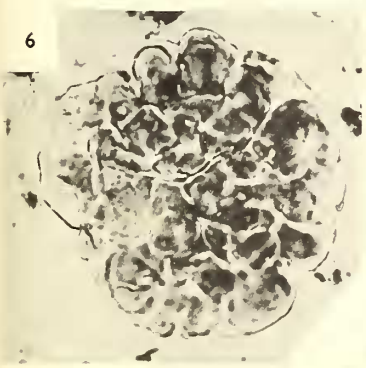


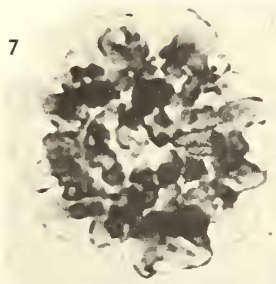



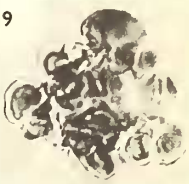


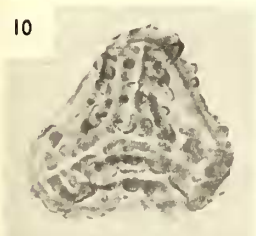


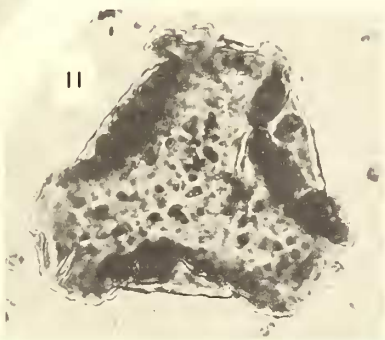









NEVES, Namurian microspores

*Dictyotriletes varioreticulatus* Neves 1958

*Occurrence.* Upper Namurian B–Westphalian A, common in some coals.

Genus CONVOLUTISPORA Hoffmeister, Staplin and Malloy 1955

*Type species. C. florida* Hoffmeister, Staplin and Malloy 1955

*Convolutispora* sp. *A*

Plate 32, fig. 2

*Description.* One specimen only, size 122 $\mu$. Equatorial outline $\pm$ circular, margin sinuous to smoothly indented. Trilete rays three-quarters spore radius, sutures thin. Exine with broad anastomosing ridges, 6–10 $\mu$ wide, and which form an irregular reticulum when seen in high focus.

*Comparison.* The organization of the ridges is somewhat similar to that present in *C. mellita* Hoffmeister, Staplin, and Malloy.

*Occurrence.* Marine shale with *Gastrioceras cancellatum*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

*Convolutispora obliqua* sp. nov.

Plate 32, fig. 3

*Holotype.* Plate 32, fig. 3.

*Type locality.* Marine shale with *Eumorphoceras bisulcatum*, Bagnall, Staffordshire (Loc. 2). Arnsbergian stage.

*Diagnosis.* Size range 100–130 $\mu$ (twenty specimens measured), holotype 122 $\mu$; equatorial outline subcircular, spores usually compressed obliquely; exine with an ornament of long, anastomosing ridges, 2–5 $\mu$ high, 1–6 $\mu$ wide, and up to 25 $\mu$ long.

*Description.* Colour brown. Trilete rays two-thirds to three-quarters radius of the spores, slightly flexuous due to the ornament, suture and lips narrow. The sinuous, anastomosing ridges appear at the spore margin as subconical processes with rounded or flattened crests. Between the ridges there appear narrow channels of thinner exine. Secondary folds of the exine are infrequently present.

*Comparison. C. mellita* and *C. tessellata* are smaller, and the ridges in these species are shorter with less tendency for the linear disposition present in *C. obliqua. C. flexuosa* has flatter, more widely spaced ridges.

*Convolutispora laminosa* sp. nov.

Plate 32, figs. 4, 5

*Holotype.* Pl. 32, fig. 4.

*Type locality.* Marine shale with *Gastrioceras cancellatum*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

*Diagnosis.* Size range 50–80 $\mu$ (twenty specimens measured), holotype 72 $\mu$; equatorial outline subcircular; exine characterized by broad regions of thickening which are sinuous in outline.

*Description.* Colour brown. Trilete rays hair-like, two-thirds to three-quarters radius of the spores. The exine of these spores bears extensive regions of thickening, between which narrow channels of thin exine are to be found. Locally the patches of thickening break up into broad, flat, ± linear ridges. Thickenings 5–20 $\mu$ wide, length variable.

*Comparison.* In all other described species of *Convolutispora* the linear, sinuous ornamentation ridges predominate.

*Occurrence.* Namurian B–C, restricted to marine shale assemblages where the species is sometimes fairly common.

### Genus MICRORETICULATISPORITES (Knox) Potonié and Kremp 1954

*Type species. M. lacunosus* (Ibrahim) Knox 1950

*Microreticulatisporites concavus* Butterworth and Williams 1958

*Occurrence.* Namurian A, rare and restricted to marine shale assemblages.

### Series PSEUDOCINGULATI ser. nov.

This Series is proposed for those miospores in which the ornamentation of the exo-exine, large warts and lobate outgrowths, extends beyond the line of the spore body membrane (int-exine) in the equatorial region. The compressed spores are consequently characterized by a marked outer marginal rim which is deeply dissected and often discontinuous.

*Comparison.* Spores of the Series Membranati ser. nov. differ in that the exo-exine is membranous and encloses the spore body partially or completely, in the manner of a mantle.

*Remarks.* The outer zone of these spores is not a true cingulum in the sense of a continuous equatorial structure of the type present in *Densosporites*, *Lycospora*, &c. The peripheral zone in the Pseudocingulati arises as a result of the compression of upstanding ornamentation elements which overlap laterally at the spore margin.

### Genus SECARISPORITES gen. nov.

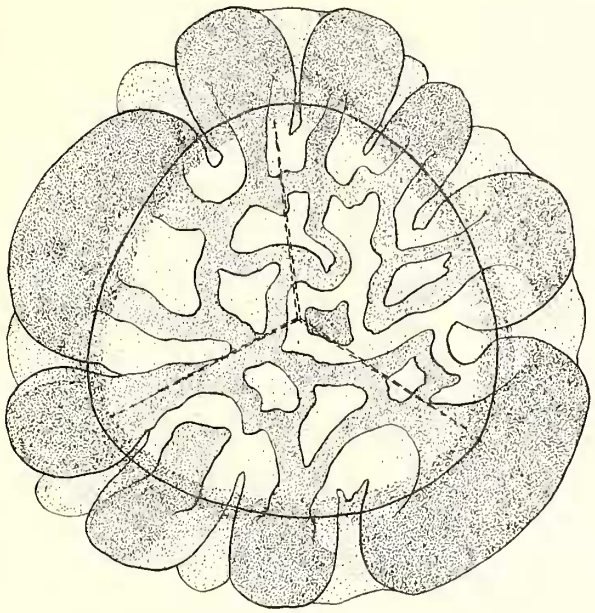
Text-fig. 2

*Type species. S. lobatus* sp. nov.

*Diagnosis.* Trilete, iso- or microspores, equatorial outline subcircular, ovate to subtriangular. The exo-exine is expanded into a series of lobate outgrowths which are of such dimensions as to give rise to an outer zone or pseudo-flange in the compressed spores. The outer zone is not continuous and deep indentations frequently occur between the bulbous lobes. The distal polar region of the spores is covered by an ornament of loosely spaced ridges and warts.

*Remarks.* The distal ornamentation found in some of these spores closely resembles that seen in spores of the genus *Convolutispora* Hoffmeister, Staplin, and Malloy 1955. However, the lateral overlap and fusion of the ornamentation elements in the region of

the equator give rise to the discontinuous peripheral rim which characterizes the spores of this genus. With careful focusing, the spore body outline can be distinguished as a sharp line of regular form, lying ± concentric with the spore outline (Pl. 32, figs. 6 and 9). Hacquebard and Barss (1957, pl. vi, figs. 11, 12) illustrate Spore Type A, which



TEXT-FIG. 2. *Secarisporites* gen. nov. Diagrammatic reconstruction; distal surface.

closely resembles in structural oganization spores which are here attributed to the genus *Secarisporites*.

*Secarisporites lobatus* sp. nov.

Plate 32, figs. 6, 7

*Holotype*. Plate 32, fig. 6.

*Type locality*. Marine shales with *Gastrioceras cancellatum*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

*Diagnosis*. Size range 55–85 $\mu$ (twenty specimens measured) holotype 81 $\mu$; equatorial outline subcircular, margin lobate and deeply incised; trilete rays thin, reaching to the inner limit of the peripheral zone.

*Description*. Colour medium to dark brown. Equatorial outline of the spore body rounded triangular to subcircular, outer margin of the enclosing rim is ± conformable. The 'pseudoflange' is composed of lobate outgrowths of the exine, which extend 10–18 $\mu$ beyond the spore body wall. Between the rounded, in part overlapping, lobes the rim is deeply incised. The distal polar region is decorated with rounded thickenings and irregular, linear ridges.

*Comparison*. The spores of this species are characterized by the wide, dissected marginal

rim. In *Secarisporites remotus* the rim consists of more widely spaced elements, and the spores are smaller.

*Secarisporites remotus* sp. nov.

Plate 32, figs. 8, 9

*Holotype*. Plate 32, fig. 9.

*Type locality*. Non-marine roof shales of the Pot Clay Coal, Holymoorside, Derbyshire (Loc. 13). Yeadonian stage.

*Diagnosis*. Size range 35–50 $\mu$ (fifteen specimens measured), holotype 46 $\mu$; equatorial outline triangular, subcircular to ovate; exine ornamented with narrow ridges and small warts; outline of spore with rounded lobes of variable size.

*Description*. Colour brown. Trilete rays thin, reaching to the line of the spore body wall, often obscured by the ornamentation elements. The spore outline is strongly lobate with elements of variable size and lateral continuity, height 2–8 $\mu$ and up to 12 $\mu$ wide. Over the distal surface of the spores the ornamentation consists of narrow ridges and discrete wart-like thickenings.

*Comparison*. These spores are characterized by their small size, the variable size and often isolated nature of the peripheral lobes.

*Occurrence*. Upper Namurian B–Namurian C, rare.

Division ZONALES (Bennie and Kidston) Potonié 1956
Group AURITOTRILETES Potonié and Kremp 1954
Series AURICULATI (Schopf) Potonié and Kremp 1954
Genus AHRENSISPORITES Potonié and Kremp 1954

*Type species*. *A. guerickei* (Horst) Potonié and Kremp 1954.

*Remarks*. Potonié (1956, p. 16) transferred the genus *Ahrensisporites* to the Series Laevigati, Subdivision Azonotriletes. Based on observations made during the present study, the current author retains the genus in the original supra-generic position suggested by Potonié and Kremp (1954, p. 155).

*Ahrensisporites beeleyensis* sp. nov.

Plate 32, fig. 10

*Holotype*. Plate 32, fig. 10.

*Type locality*. Non-marine shales with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

*Diagnosis*. Size range 45–60 $\mu$ (twenty specimens measured), holotype 56 $\mu$; equatorial outline triangular, sides straight to slightly concave, apices rounded; kyrtome built up from a series of small, bluntly conical elements, which also occur scattered in the inter-radial regions.

*Description*. Colour golden-brown to brown. Exine laevigate between the ornamentation elements. Trilete mark simple, rays straight, three-quarters radius of the spores. Small blunted cones are serially arranged on the distal surface of the spores, giving rise to the characteristically dentate kyrtome. The elements are closely spaced and the bases are fused in part. Scattered cones are found also in the inter-radial regions.

*Comparison.* The presence of a composite kyrtome, constructed from discrete, regularly arranged, small blunted cones, distinguishes the spores of this species. Little morphological variation has been observed in this species group.

*Occurrence.* Upper Namurian B–Namurian C appears to be more characteristic of non-marine shale assemblages.

*Ahrensisporites guerickei* Horst 1955

*Occurrence.* Upper Namurian B–Westphalian A, common in certain assemblages.

*Ahrensisporites guerickei* var. *ornatus* var. nov.

Plate 32, fig. 11

*Holotype.* Plate 32, fig. 11.

*Type locality.* Marine shales with *Eumorphoceras bisulcatum*, Bagnall, Staffordshire (Loc. 2). Arnsbergian stage.

*Diagnosis.* Size range 65–80 $\mu$ (twenty specimens measured), holotype 77 $\mu$; equatorial outline triangular, sides straight or slightly convex, apices somewhat truncate; kyrtome arise from strong folds of the exine of the distal surface; spore body decorated with irregularly, rounded thickenings.

*Description.* Colour yellow-brown, kyrtome and exinous thickenings darker. Trilete rays simple, straight, three-quarters spore radius. The exine of the distal surface is ornamented with irregular thickenings of a wart-like nature. The kyrtome is a more or less continuous, heavy wall which, when compressed beyond the outline of the spores, appears to be 7–10 $\mu$ high.

*Remarks.* A clearly defined group of spores, closely comparable to the holotype of *Ahrensisporites guerickei* figured by Horst (1955, pl. 7, fig. 58), appears in the upper part of the Marsdenian stage (Namurian B) and persists into the Westphalian measures of the English Central province. In addition, a variety of *A. guerickei* (designated above) possessing an ornamentation of irregular exinous thickenings similar to the forms figured by Horst (1955, pl. 7, fig. 61) and Butterworth and Williams (1958, pl. iii, fig. 18) has been found during the current study to persist throughout the Namurian succession from the Arnsbergian stage to the Lower Westphalian horizons.

Genus TRIQUITRITES (Wilson and Coe) Potonié and Kremp 1954

*Type species. T. arculatus* Wilson and Coe 1940

*Triquitrites nodosus* sp. nov.

Plate 32, fig. 12 and Plate 33, fig. 1

*Holotype.* Plate 32, fig. 12.

*Type locality.* Non-marine shale with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

*Diagnosis.* Size range 80–95 $\mu$ (fifteen specimens measured), holotype 88 $\mu$; equatorial outline triangular, sides straight to slightly convex, apices broadly rounded; valvae broad, protruding slightly at the equatorial margin; distal surface of the spores is ornamented by conical to wart-like elements.

*Description.* Colour light brown, valvae darker. Trilete rays two-thirds to three-quarters radius of the spores. The valvae are centrifugal thickenings of the exine in the radial positions, projecting 3–5 $\mu$ beyond the general equatorial outline. The margins of the valvae are somewhat angular and resemble the upper part of a partially opened fan, arising from the distal surface of the apices. Blunted cones and warts are dispersed randomly over the distal surface of the spores.

*Comparison.* The spores of this species are distinguished by their large size, the arcuate form of the valvae, and the nature of the distal ornamentation. *Triquitrites verrucosus* Alpern 1958 is smaller and is recorded from much higher horizons.

Group ZONOTRILETES Waltz 1935
Series CINGULATI Potonié and Klaus 1954
Genus DENSOSPORITES (Berry) Potonié and Kremp 1954

*Type species. D. covensis* Berry 1937

*Densosporites spinosus* Dybova and Jachowicz 1957

*Occurrence.* Namurian A–B, common in some marine shale and coal seam assemblages.

*Densosporites vulgaris* sp. nov.

Plate 33, fig. 2; text-fig. 3

*Holotype.* Plate 33, fig. 2.

*Type locality.* Pot Clay Coal, Holymoorside, Derbyshire (Loc. 13). Yeadonian stage.

*Diagnosis.* Size range 50–65 $\mu$ (twenty-five specimens measured), holotype 59 $\mu$; equatorial outline rounded triangular; trilete rays thin, reaching almost to the spore body wall; contact region thickened; cingulum smooth with slight equatorial taper.

*Description.* Colour light brown to yellowish. Equatorial margin generally smooth, occasionally a few scattered coni may be present. The cingulum has a faint radial, fibrous structure, an ill-defined inner thickened zone and a gradual equatorial taper. Inner thickened zone one-quarter to one-third width of the cingulum and overlapping the spore body margin 2–3 $\mu$, proximally. The proximal polar region bears a thickened contact area, the outer margin of which is concentric with the spore body outline and lies 4–7 $\mu$ nearer the proximal pole. The exine of the spore body is laevigate to faintly infra-punctate.

*Remarks.* The spores of this species are characterized by the thickened proximal polar region.

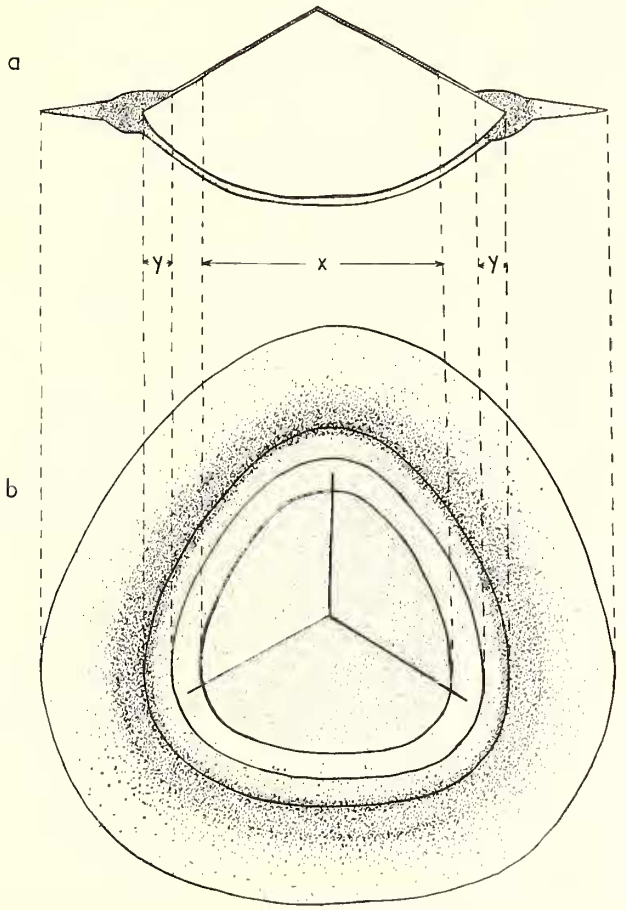
Genus KNOXISPORITES Potonié and Kremp 1954 emend.

*Type species. K. hageni* Potonié and Kremp 1955.

*Emended diagnosis.* Trilete iso- or microspores with an equatorial cingulum which is of more or less uniform thickness throughout its width, possibly tapering slightly in the immediate vicinity of the equator. The distal hemisphere of the spores is characterized by a variable pattern of radial and/or concentric bands of thickening. The equatorial outline of the cingulum is more or less conformable to that of the spore body, only

departing from it locally where the fusion of radial elements and the equatorial girdle produces a swollen node of thickening. Small thickened lobes may project from the cingulum on to the proximal surface of the spore body.

*Remarks*. From a critical study of author's photographs and descriptions, it becomes




TEXT-FIG. 3. *Densosporites vulgaris* sp. nov. Diagrammatic reconstruction; *a*, polar section; *b*, proximal polar view.

apparent that the majority of spores allocated to the genus *Knoxisporites* Potonié and Kremp 1954 possess an equatorial extension of the exo-exine in the form of a cingulum. In the diagnosis of the type species, *K. hageni* Potonié and Kremp (1955, p. 116), the authors repeatedly refer to the presence of a cingulum. At the same time, the figure of the holotype (pl. 16, fig. 316) clearly shows the presence of a continuous equatorial girdle or cingulum. Similarly, Hoffmeister, Staplin, and Malloy (1955, p. 391), in considering *K. triradiatus*, discuss the structure in terms of 'a central body' and an 'equatorial girdle'. Furthermore, whilst the disposition of the distal thickenings varies considerably in the species groups, the equatorial girdle remains a constant feature. It is not

a question of muri lying parallel with equator, as in *Reticulatisporites*, but of a definite equatorial structure, as was indeed suggested by Potonié and Kremp (1955) for the type species.

Since the presence of a cingulum has been used by Potonié and Kremp (1954) as the major criterion in the definition of the Series Cingulati, the genus *Knoxisporites* is here transferred to this Series.

*Comparison.* *Simozonotriletes* is characterized by a triangular equatorial outline. *Stenozonotriletes* (Naumova) Hacquebard 1957 has no thickened bars on the distal surface. *Cincturasporites* Hacquebard and Barss 1957 possesses a thickened equatorial girdle which partly overlaps the spore body polewards.

### *Knoxisporites dissidius* sp. nov.

Plate 33, figs. 4, 6; text-fig. 4

*Holotype.* Plate 33, fig. 4.

*Type locality.* Non-marine roof shales of the Pot Clay Coal, Holymoorside, Derbyshire (Loc. 13). Yeadonian stage.

*Diagnosis.* Size range 50–80 $\mu$ (twenty-five specimens measured), holotype 70 $\mu$; equatorial outline somewhat hexagonal, margin slightly irregular; outline of the spore body rounded triangular; distal surface of the spores with a Y-shaped thickening, distal polar region unthickened.

*Description.* Colour yellow to brown. The hexagonal tendency of the equatorial outline is due to the prolongation of the radial bars of thickening on to the cingulum. Outline of the spore body clearly defined, rounded triangular. Trilete rays three-quarters radius of the spore body, lips thin. Cingulum fleshy, tapering only slightly towards the equatorial margin. The distal surface of the spores bears three radial bars of thickening which are rotated 60° relative to the rays of the trilete mark. The thickened bars unite over the distal surface of the spore body to enclose a circular to triangular region of unthickened exine at the distal pole. Subsidiary bars of thickening often appear proximally in the cingulum, opposite the ends of the trilete rays. Exine laevigate to infra-punctate.

*Remarks.* The spores of *K. dissidius* are distinguished by the rounded triangular spore body, the slightly discordant fleshy cingulum, and the pattern of distal thickenings.

*Occurrence.* Namurian A–Westphalian A, rare.

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EXPLANATION OF PLATE 33

All magnifications × 500.

Fig. 1. *Triquitrites nodosus* sp. nov., 87 $\mu$.

Fig. 2. *Densosporites vulgaris* sp. nov., holotype, 59 $\mu$, proximal view. Slide ref. 9.177820.

Fig. 3. *Cirratriradites ornatus* sp. nov., holotype, 92 $\mu$, distal view, low focus. Slide ref. s.Al.

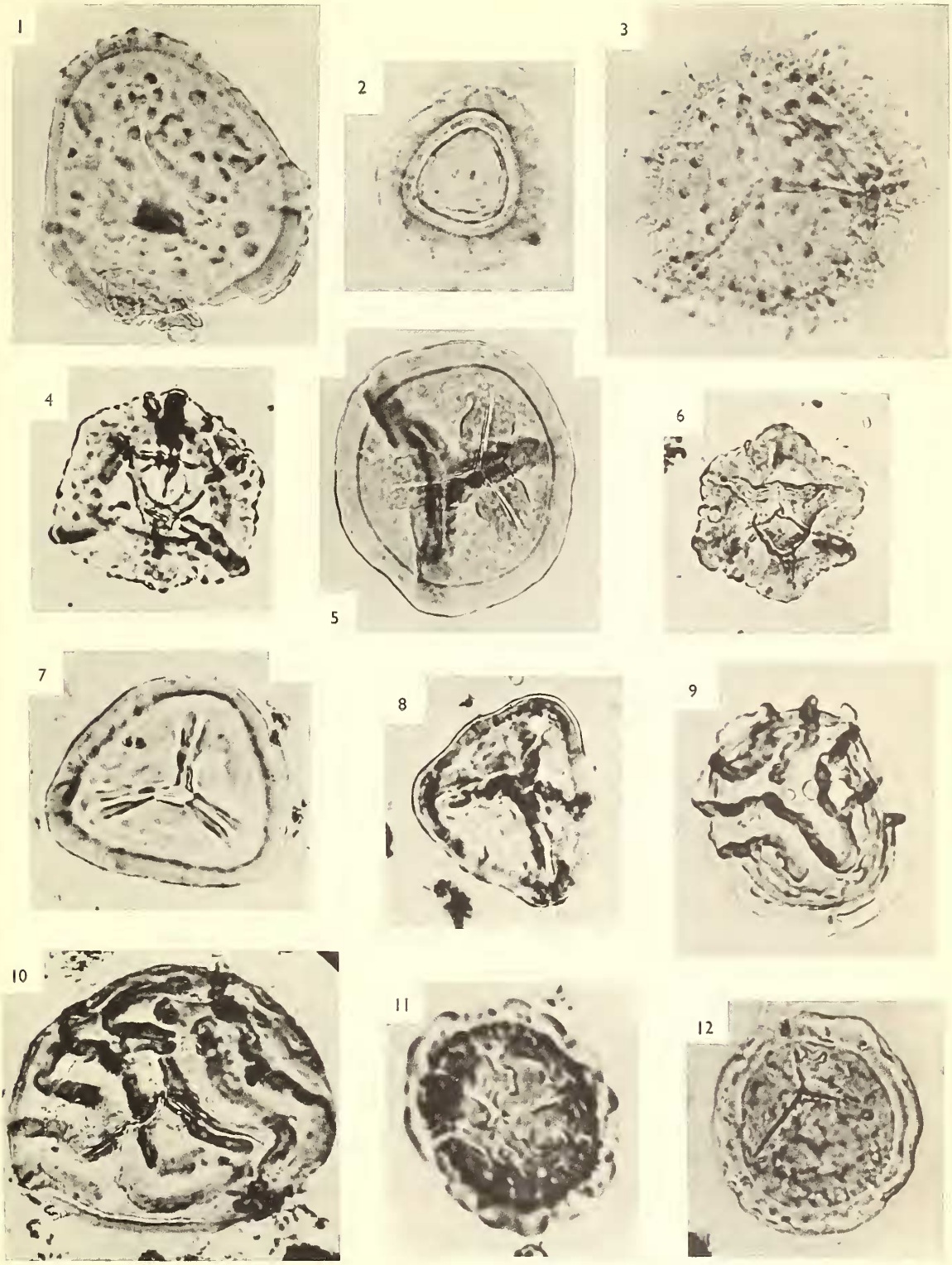
Figs. 4, 6. *Knoxisporites dissidius* sp. nov. 4, Holotype, 70 $\mu$, distal view, low focus. Slide ref. 4.307719. 6, Distal view, 56 $\mu$.

Fig. 5. *K. seniradiatus* sp. nov., holotype, 88 $\mu$, proximal view, low focus. Slide ref. s.Bf.

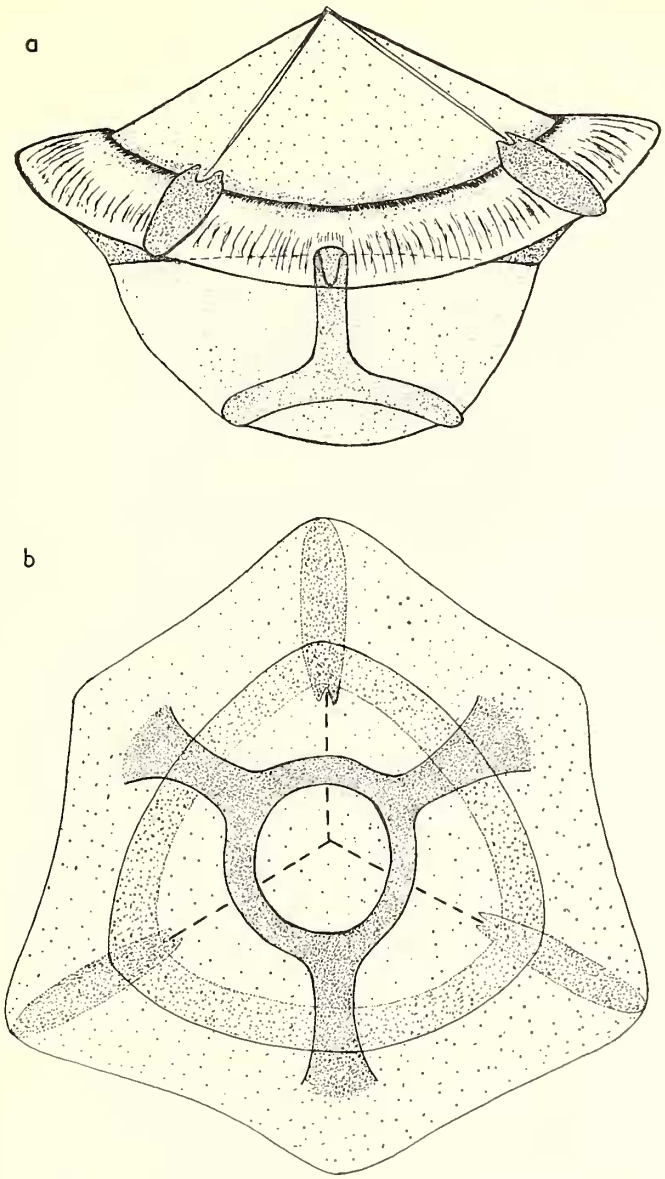
Figs. 7–8. *Stenozonotriletes triangulus* sp. nov. 7, Holotype. 77 $\mu$, proximal view. Slide ref. 1.361656. 8, Proximal view, 65 $\mu$.

Figs. 9–10. *Proprisporites laevigatus* sp. nov. 9, Holotype, 77 $\mu$, distal view, low focus. Slide ref. 5. 304770. 10, Proximal view, low focus, 101 $\mu$.

Figs. 11–12. *Hymenospora palliolata* sp. nov. 11, Holotype, 87 $\mu$, distal view. Slide ref. 8.319715. 12, 74 $\mu$.




NEVES, Namurian microspores




TEXT-FIG. 4. *Knoxisporites dissidius* sp. nov. Diagrammatic reconstruction; *a*, elevation; *b*, distal polar view.

## *Knoxisporites seniradiatus* sp. nov.

Plate 33, fig. 5

*Holotype*. Plate 33, fig. 5.

*Type locality*. Non-marine shales with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

*Diagnosis.* Size range 60–105 $\mu$ (twenty specimens measured), holotype 88 $\mu$; equatorial outline of the spore body subcircular; distal surface with tri-radial bars of thickening, rotated 60° relative to the trilete rays of the proximal surface; rays of the trilete mark with prominently thickened lips.

*Description.* Colour light brown. Outline of the spore body sharp; equatorial girdle is of uniform width. Trilete rays three-quarters radius of the spore body, tecta sharp and straight; lips associated with prominent bands of thickening, 5–7 $\mu$ wide, margin away from the suture often slightly undulating. Cingulum 6–14 $\mu$ wide. The Y-shaped bars of distal thickening, 6–10 $\mu$ wide, often persist into the cingulum. Exine faintly infra-punctate.

*Comparison. Knoxisporites triradiatus* is very similar, but the spores of that species lack the prominent thickenings which in *K. seniradiatus* are associated with the trilete rays.

*Occurrence.* Namurian B–C, rare.

Genus STENOZONOTRILETES (Naumova) Hacquebard 1957

*Type species. S. conformis* Naumova 1953

*Stenozonotriletes triangulus* sp. nov.

Plate 33, figs. 7, 8

*Holotype.* Plate 33, fig. 7.

*Type locality.* Marine shales with *Gastrioceras cancellatum*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

*Diagnosis.* Size range 60–80 $\mu$ (twenty-five specimens measured), holotype 77 $\mu$; equatorial outline triangular, sides straight to slightly convex, apices rounded; equatorial girdle narrow, 4–8 $\mu$ wide, and smooth.

*Description.* Colour yellowish-brown. Trilete rays three-quarters radius of the spore body, lips often associated with small folds of the exine which taper towards the proximal pole; a darker contact region is often present. The equatorial girdle is of uniform width and possesses little or no equatorial taper. Exine laevigate to slightly infra-punctate.

*Comparison. Stenozonotriletes conspersus* Naumova 1953 is of similar shape but is smaller.

Genus CRASSISPORA Bhardwaj 1957

*Type species. C. ovalis* Bhardwaj 1957

*Crassispora kosankei* (Potonié and Kremp) Bhardwaj 1957

*Occurrence.* Namurian B–Westphalian A, occasionally common in certain coal-seam and non-marine shale assemblages. The first appearance of this species can be correlated accurately with measures of Namurian B age.

Series ZONATI Potonié and Kremp 1954

Genus CIRRATRIRADITES Wilson and Coe 1940

*Type species. C. saturni* (Ibrahim) Schopf, Wilson and Bentall 1944

*Cirratriradites ornatus* sp. nov.

Plate 33, fig. 3

*Holotype.* Plate 33, fig. 3.

*Type locality.* Non-marine shale with *Carbonicola exporrecta*, Hipper Sick, Derbyshire (Loc. 12). Yeadonian stage.

*Diagnosis.* Size range 80–110 $\mu$ (fifteen specimens measured), holotype 92 $\mu$; equatorial outline rounded triangular; trilete rays are associated with long folds which extend on to the thin, fibrous zona; the whole of the distal surface of the spores is beset with dispersed coni.

*Description.* Colour light brown, zona pale yellow-brown. Exine of the spore body punctate; decorated on the distal surface with delicate cones and small spines. The zona has a radial fibrous appearance, width 14–20 $\mu$. Where the zona passes over the spore body margin, a darker band, 7–10 $\mu$ wide, is present. No foveae are present.

*Remarks. C. ornatus* is distinguished by its large size, the ornamentation of the distal surface, and the lack of foveae.

*Occurrence.* Namurian C, present in non-marine shales only, rare.

Series MEMBRANATI ser. nov.

This series is proposed for those trilete iso- or miospores in which the outer membrane of the exine, the exo-exine, has partially separated from the inner membrane or intexine, and projects at the spore margin as a clear, thin membrane. The two membranes may be attached to one another only in the region of the trilete mark, or the exo-exine can be arranged as a series of folds which run over the surface of the spore body membrane.

*Remarks.* The infra-reticulate structure which characterizes the cavity between the spore body wall and the saccus membrane, in many forms attributed to the Division Sacciti, is never present in the Series Membranati.

Genus PROPRISPORITES Neves 1958

*Type species. P. rugosus* Neves 1958

*Proprisporites laevigatus* sp. nov.

Plate 33, figs. 9, 10

*Holotype.* Plate 33, fig. 9.

*Type locality.* Marine shales with *Hudsonoceras proteum*, Congleton Edge ganister quarry, Staffordshire (Loc. 4). Sabdenian stage.

*Diagnosis.* Size range 70–115 $\mu$ (fifteen specimens measured), holotype 77 $\mu$; equatorial outline of the spore body rounded triangular; trilete rays three-quarters radius of the spore body; exo-exine translucent, laevigate and strongly folded over the laevigate spore body.

*Description.* Colour light brown; exine laevigate. Spore body compact, outline smooth and regular. The outer spore membrane is plicated into a series of sinuous folds which

run over the surface of the spore body. The folds in places lie parallel to the compressed spore margin, where they appear as membranous projections; they may also appear as subconical projections at the spore outline when the fold axis lies at an angle to the outline.

*Comparison*. The only other described species of this genus, *P. rugosus*, is distinguished by the strong punctation of the spore body membrane.

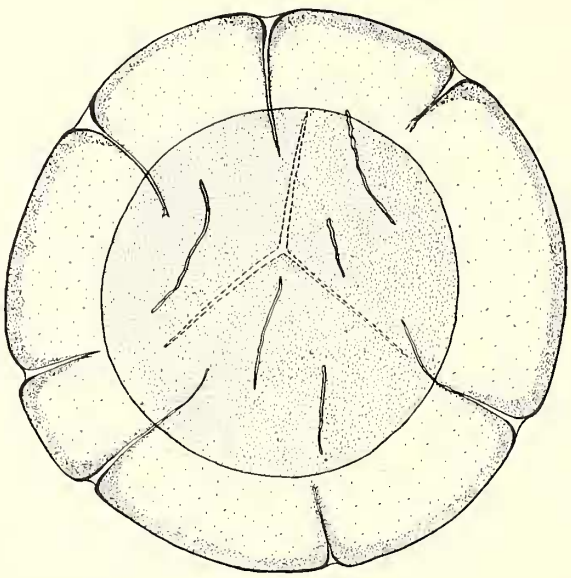
*Occurrence*. Namurian A–B, more typical of the marine shale assemblages.

### Genus HYMENOSPORA gen. nov.

Text-fig. 5

*Type species*. *H. palliolata* sp. nov.

*Diagnosis*. Trilete iso- or microspores; equatorial outline circular to subcircular. The exo-exine is attached to the int-exine in the region of the trilete mark. In addition the



TEXT-FIG. 5. *Hymenospora* gen. nov. Diagrammatic reconstruction; distal surface.

exo-exine is deeply furrowed, and along the troughs of the furrows the two membranes are still in contact. In the compressed spores the exo-exine projects beyond the body margin as a laevigate, membranous zone.

*Remarks*. The zonate aspect of these spores is due entirely to the marginal projection of the exo-exine, and the outer zone is not necessarily in the equatorial position relative to the trilete mark, an essential character of the Series Cingulati and Zonati. The outer membrane, although detached for the greater part from the int-exine, is fairly rigid due to the subsidiary lines of adhesion along the furrows in the exo-exine.

*Hymenospora palliolata* sp. nov.

Plate 33, figs. 11, 12

*Holotype.* Plate 33, fig. 11.

*Type locality.* Marine shales with *Gastrioceras cancellatum*, Crowborough Wood, Staffordshire (Loc. 10). Yeadonian stage.

*Diagnosis.* Size range 70–105 $\mu$ (twenty specimens measured), holotype 87 $\mu$; equatorial outline subcircular; trilete rays sharp, three-quarters radius of the spore body; exo-exine laevigate and crenulate.

*Description.* Colour of spore body light brown, outer membrane pale yellow; exine laevigate. Trilete rays three-quarters spore body radius, tecta tapering, lips thin. The mantle-like outer membrane is wrinkled into a series of narrow linear furrows, along which lines it is attached to the inner membrane. The two membranes are also in contact in the region of the trilete mark. In the compressed spores the exo-exine projects beyond the margin of the spore body as a more or less uniform rim with an outer crenulate border. An original globular form of these spores is indicated by the frequent oblique compression.

*Comparison.* Knox (1947, pl. 6, fig. 54) illustrates Spore Type 46K from the Limestone Coal Group of Scotland (Namurian A); this form closely resembles *Hymenospora palliolata.*

*Occurrence.* Namurian A and Namurian C, marine-shale assemblages only, rare.

Series PATINATI Butterworth and Williams 1958

Genus *Tholisporites* Butterworth and Williams 1958

*Type species. T. scoticus* Butterworth and Williams 1958

*Tholisporites*? *bianulatus* sp. nov.

Plate 34, fig. 2; text-fig. 6

*Holotype.* Plate 34, fig. 2.

*Type locality.* Marine shales with *Eumorphoceras bisulcatum* Girty, Bagnall, Staffordshire (Loc. 2). Arnsbergian stage.

*Diagnosis.* Size range 55–90 $\mu$ (twenty specimens measured), holotype 80 $\mu$; equatorial outline circular, spores commonly preserved in the lateral position; two raised bands of thickening encircle the spores subequatorially; a large circular patch of thickening is centred on the distal pole.

*Description.* Colour: thickenings dark brown; remainder of the exine pale brown. Exine laevigate to faintly infra-punctate. The spores are usually compressed in the plane of the polar axis, indicating an original spherical to subspherical form. Trilete rays two-thirds radius of the spores. The exine bears two thickened bands, 7–20 $\mu$ wide, which lie adjacent to the equator, displaced slightly on to the proximal and distal hemispheres. These annular bands are separated by a channel of thinner exine, which appears as a rounded depression at the spore margin. The distal polar region is contained within a broad, circular patch of thickening, up to 45 $\mu$ in diameter, and which is separated from